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Brain Machine Interface (BMI) for Spinal Injuries

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***Abstract*— *Brain-to-machine-interface (BMI) that facilitates the healing of Spinal Injuries. The Product is designed to facilitate the healing of scar tissues along the vertebrae column. This works perfectly for persons having a handicap that hinders motor skills. The BMI performs this operation by generating a series of electro-magnetic propagations throughout the vertebrae column. It will also be designed to target specific areas of extreme abrasion(s) that affect proper blood flow to facilitate the easy flow of blood (as before injury), so that patient(s) once again would experience the use of their limbs. The device will be engineered as such to cause the brain, where necessary, to (possibly) adjust its own internal frequencies (in Hz) and pitch (in W s/cm^2) to aid in this process. It will be disclosed that through the adjustment of frequencies (in Hz) and energy density (in W s/cm2) scar tissues can be corrected.*

***Keywords*— Brain Machine Interface, Spinal Injuries, Transfer learning, machine learning.**

I. INTRODUCTION

Physics-Based Transfer Learning is where one trains a model to perform a task and then uses the information/knowledge acquired in the completion of another task. It deeply involves the transferal of information from one experience and applying such to another situation under a similar heading. This greatly will improve efficiency of a learning agent.

> Transfer learning (TL) is a research problem in machine learning (ML) that focuses on…reusing or transferring information from previously learned tasks for the learning of new tasks…[3][4]

> Dopamine is a neuromodulator responsible for playing a crucial roles learning, motor control and memory along with addictive behaviour development. Most dopaminergic neurons are based in two nuclei, substantia nigra compacta and the ventral tegmental area. Exciting of these neurons in animal learning has been well characterized in mammals. Schultz and colleagues examined the live activities of dopaminergic neurons in certain tasks for training. In the study conducted, the activity of dopaminergic neurons seems to display internal expectations and outcomes for anticipation of failure. Hence, the dopamine system gives information with respect to environmental stimuli for information capture and synthesis.

II. THE HUMAN BRAIN: NEURO-TRANSMITTANCE

Dopamine, serotonin, or acetylcholine are critical in the brain's state-dependent modulation. These neurotransmitters/ neuromodulators are conjured and dispatched from specialized neurons (small in number) located in forebrain, mid-brain and brain-stem of the brain. Synaptic contacts with varied areas of the brain are made with long-range neuro-transmitting connections. Neuromodulators dispatched from synaptic terminals are able to travel over 10 μm and acts on receptors distanced from release sites. Neuromodulators released from synaptic terminals are also capable of diffusing over substantial distances (>10 μm) (volume transmission; Venton et al., 2003; Zoli et al., 1998). [1] The information from neuromodulation/ neuro-transmitting neurons are propagated to large area(s) of the brain at the apparent cost of spatial selectivity. As such, activity changes in a small number of neurons can exert a broadcast influence on many brain areas, coordinating a functional change across areas (Hasselmo, 1995). [1]

> The activities of the brain are recognized as varied frequencies of multiple oscillations in electroencephalograms. There have been studies linking brain functions with specific oscillatory activities. These oscillatory activities are not just epiphenomena, but the brain appears to utilize them for information coding (Engel et al., 2001; Varela et al., 2001). [1][6] Selecting activities locked in phases and information binding in the

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cortex of the brain, are typical examples. Brain oscillations is vital in the regulation of information traffic. Therefore, it is necessary to assess neural network and the manner in which they respond to frequency stimulation.

The proportion of the postsynaptic response effected as a result of presynaptic excitation is internally dependent on stimulation frequency in monosynaptic transmission. The magnitude of the postsynaptic response evoked by presynaptic stimulation is intrinsically dependent on stimulation frequency (Markram et al., 1998). [1] In the delivery of several stimuli within close periods of time, the size of postsynaptic nerves increases in size, a condition called paired-pulse depression. Both presynaptic and postsynaptic mechanisms have been implicated in these processes. [1] Changes in neurotransmitter provides possibility of readily dischargeable reservoirs of synaptic vesicles. Postsynaptic receptor desensitization (Koike-Tani et al., 2008). [1] Frequency-dependent modulation of synaptic transmission has been proven to be brought into effect by the mobility of postsynaptic receptors.

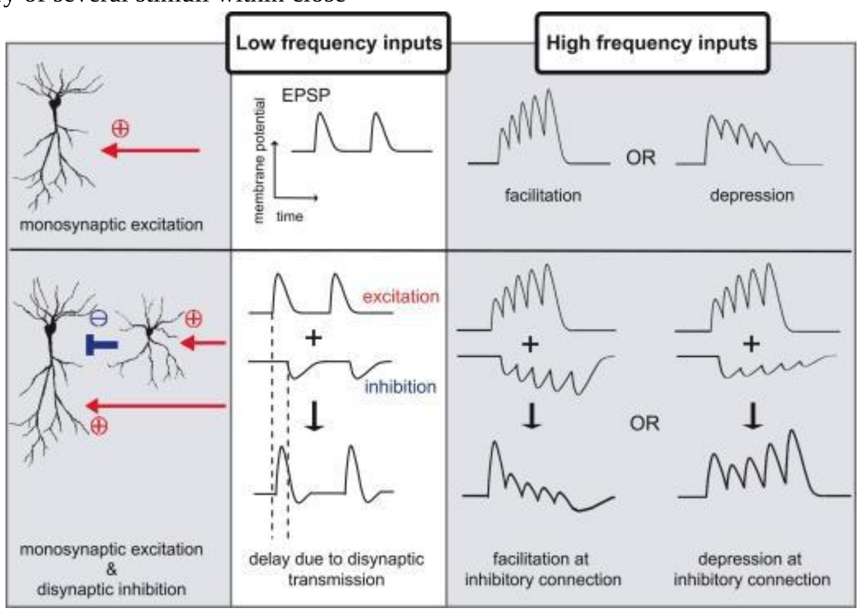

Fig.1.1: Frequency Stimulation of Synaptic Nerves

(Erin M. Schuman, 2008)

III. THE PRODUCT: GAASSI CHIP

Given the scientific data/information, the design of the BMI is such that human safety is paramount while fulfilling its objective(s).

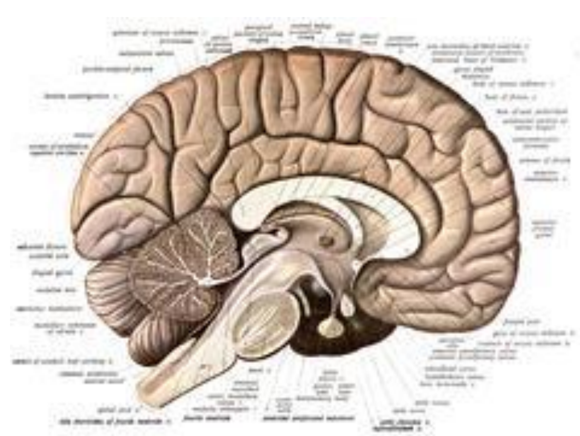

Fig.1.2: Brain Midsection

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The BMI is designed as such that there will be an implantation of a micro-processing electrode in the midsection of the brain (just at the surface (can be on either hemisphere)) to enhance its capability to transmit signal input to and receive signal output from the brain. The chip with its electrodes will be placed just above the area of the medulla oblongata and the hippocampus. The frequency transmission is said to be greatest in this region because the neurons transmits as far as 5 micrometers.

This chip will have electrodes made of Gallium Arsenide (GaAs) and Silicon (Si) (commercial type) with a length of 1mm or less (size depends on brain density of the subject) and the diameter of the same. The electrodes will consist 90% GaAs and 10% Silicon, however, this may vary depending on the situation. The reason for choice of those materials are that they facilitate high bandwidth of frequency and watt dispensation. Also, evidential research has proven that photons/phonons are very high in these materials.

This is significant as it allows for scalability and improves bandwidth through the increase of wavelengths. It must be noted also that commercial silicon has traces of Germanium, Gallium and Arsenic. These greatly help with bandwidth dispensation and power (in W s/cm2).

This GaAsSi chip will be comprised of GaAs covered in silicon with a golden crystal in the core of the chip. The diameter of this golden crystal may be anywhere in the range of 0.5 mm to 2mm diameter. At no point will the GaAs come in contact with a human cell due to its toxicity. The silicon covering inclusive of the electrodes will be approximately 1mm thick (may be more or less depending on the situation).

These become effective as it will facilitate greater throughput in conversion from binary to analog and vice versa because there will be greater capabilities to create/draw data buses in nanometric context on the circuit while matching wavelengths will exist on the analog side of the device.

From what studies show, we will be able to acquire a bandwidth of 1nHz (Nano-Hertz) from these electrodes and also able to achieve more. This fully surpasses the 10 Micro-Hertz threshold for general neuro-communication.

When the signal from the computer reaches the chip, it makes contact with the Golden crystal which becomes electrically charged. The electrically charged atoms (electrons in particular) make contact with the electrons of the GaAs through a dipole moment creating an electric field which then makes contact with electrons of the Silicon forming one field and hence one electro-magnetic field through the magnetism which takes place once the atoms of the chip combine and the chip is placed in operation. This synergy gives the chip the power (in W s/cm2) to emit at varied wattage (up to 1000 W s/cm2 and possibly greater) and frequencies (up to 1018 Hz and possibly more).

Gallium Arsenide at 300 Kelvin has an electron mobility of 9000 cm2 (Volts per second or V.s) to 10000 cm2 (Volts per second or V.s), a band gap of 1.441 eV and an electron thermal velocity of 4.4 x 105 meters per second (m/s). This makes GaAs faster than 299, 792, 458 meter per second, the very speed of light.

Below are tables displaying the electrical properties of the materials (at 300 Kelvin) of the GaAsSi chip:

Table: Gallium Arsenide

PROPERTIES	MEASURMENT
Breakdown Field	$\approx 4x10^5$ V/cm
Mobility Electrons	≤ 8500 cm^2 V^{-1} s^{-1}
Mobility Holes	≤ 400 cm^2 V^{-1} s^{-1}
Diffusion Coefficient Electrons	≤ 200 cm^2/s
Diffusion Coefficient Holes	≤ 10 cm^2/s
Electron Thermal Velocity	$4.4x10^5$ m/s
Hole Thermal Velocity	$1.8x10^5$ m/s

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Table: Silicon

PROPERTIES	MEASURMENT
Breakdown Field	≈3x10^5 V/cm
Mobility Electrons	≤1400 cm^2 V^{-1} s^{-1}
Mobility Holes	≤450 cm^2 V^{-1} s^{-1}
Diffusion Coefficient Electrons	≤36 cm^2/s
Diffusion Coefficient Holes	≤12 cm^2/s
Electron Thermal Velocity	2.3x10^5 m/s
Hole Thermal Velocity	1.65x10^5 m/s

Table: Germanium

PROPERTIES	MEASURMENT
Breakdown Field	≈10^5 V cm^{-1}
Mobility Electrons	≤3900 cm^2 V^{-1} s^{-1}
Mobility Holes	≤1900 cm^2 V^{-1} s^{-1}
Diffusion Coefficient Electrons	≤100 cm^{2}s^{-1}
Diffusion Coefficient Holes	≤50 cm^{2}s^{-1}
Electron Thermal Velocity	3.1x10^5 m s^{-1}
Hole Thermal Velocity	1.9x10^5 m s^{-1}

Table: Gold

PROPERTIES	MEASURMENT
Breakdown Field	≈10^3 V/cm
Mobility Electrons	30-50 cm^2/V.s
Mobility Holes	≈100 cm^2/V.s
Diffusion Coefficient Electrons	≈8.4x10^{-15}cm^2/s± 2.5x10^{-15} cm^2/sec (estimated error)
Diffusion Coefficient Holes	≈8.4x10^{-15}cm^2/s± 2.5x10^{-15} cm^2/sec (estimated error)
Electron Thermal Velocity	
Hole Thermal Velocity	

Figure 2.1 below displays an atom with its nucleus and electron:

Fig.2.1: Atom with its electron

Figure 2.2 below displays the atom when combined with other atoms showing how electrons move between and among other atoms representing the electric field shared:

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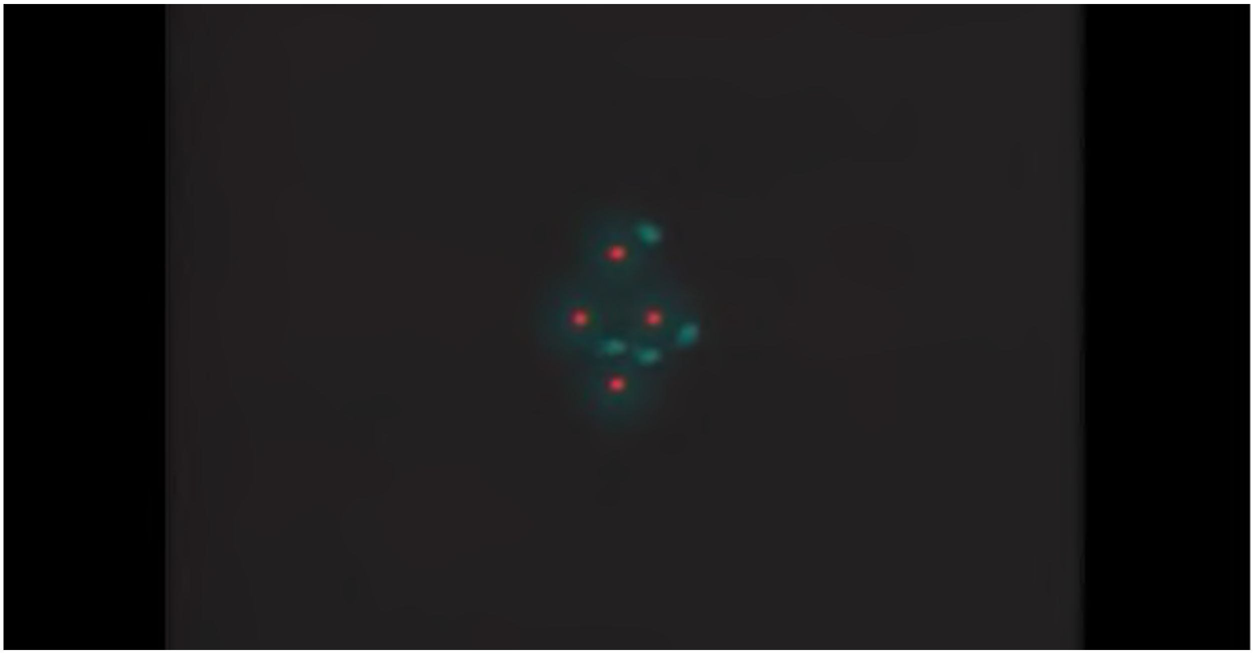

Fig.2.2: Electron Sharing

Figure 2.3 below displays the electro-magnetic field created between two atoms after a dipole moment has occurred and magnetism as a result of such:

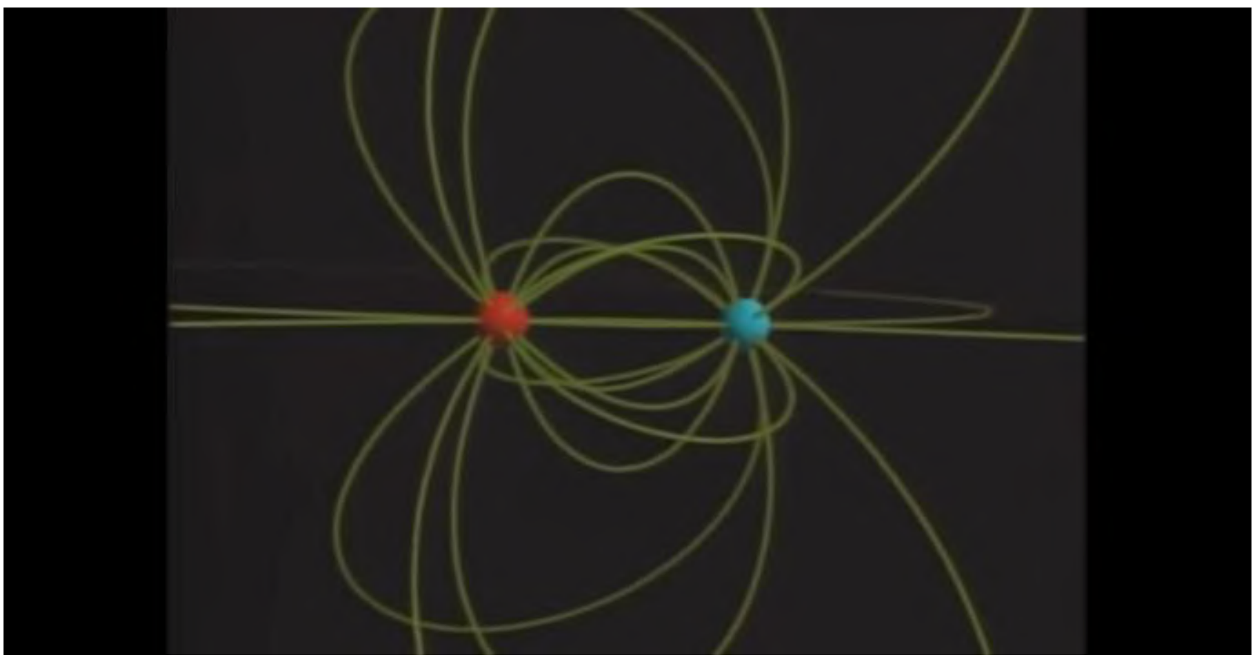

Fig.2.3: Electro-Magnetism

Notice the bond between the atomic particles and as several lines make contact, an electro-magnetic wave produces.

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The synergy of the photons (light)/phonons (sound) created by the moving electrons and holes (absence of electrons) of the atomic particles of the respective materials will generate (once photons are on the same frequency) a superimposed frequency/wavelength and hence electro-magnetic propagation.

IV. THE SPINAL VERTEBRAE COLUMN

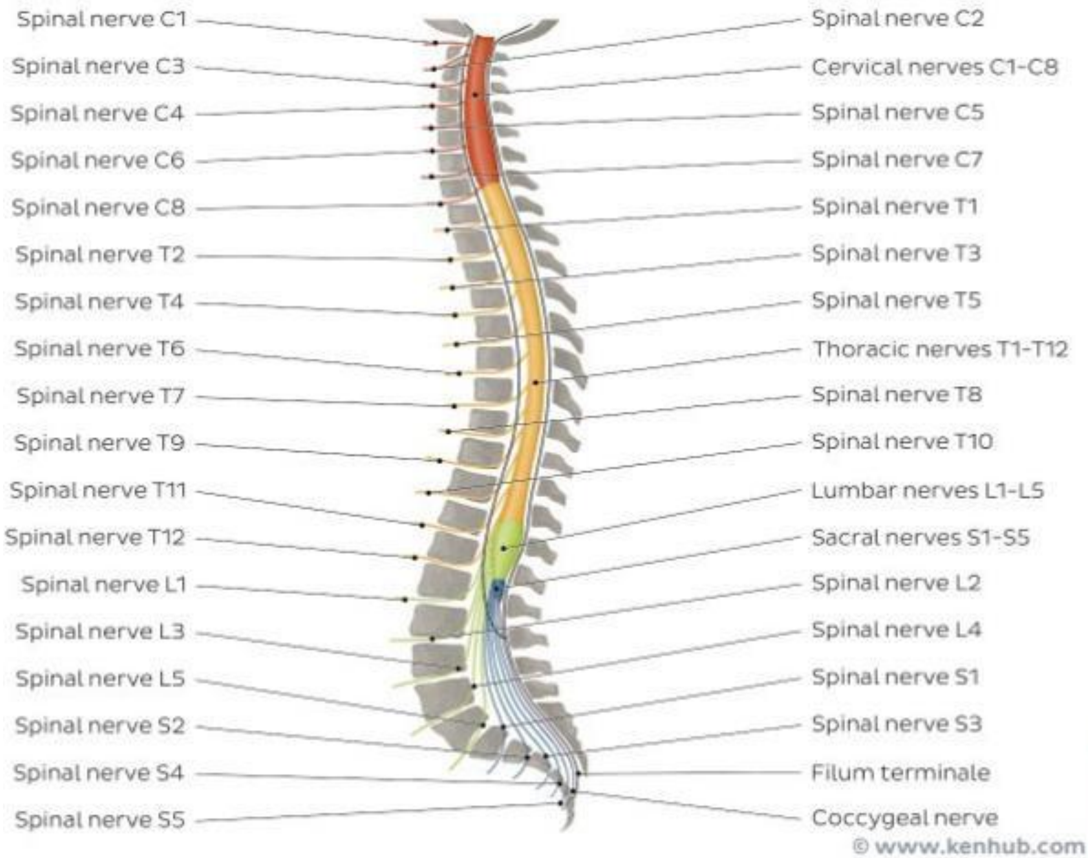

Fig.3.1: Vertebrae Column

The Spinal Cord is long, thin structure made up of nervous tissue. This runs from the medulla oblongata consisting of the hippocampus and runs downward to the lumbar region. It encases the cerebrospinal fluid. The brain and Spine is what makes up the Central Nervous System (CNS). The vertebral column is the bony structure which protects the spinal cord. It is approximately 45 cm (18 in) and around 43 cm (17 in) for women. The diameter ranges from 13 mm (1/2 in) in the cervical region and lumbar area and 6.4 mm (1/4 in) in stochastic region.

The Spine function is fundamentally responsible for the transmission of nerve signals from the motor cortex to the rest of the body. As well, carrying brain signals from the sensory afferent fibers to sensory cortex. Motor instructions are controlled by these circuit-paths.

The main component of the Nervous System are the Nervous/Neural Tissue. Body operations are managed by the nervous system. The sending and receiving of nervous impulses and neuroglia or glial cells (Schwann cells) are done by nerve cells/neurons. The glia assists with the propagation of nerve impulses and provide nutrients to the the neurons.

Nervous tissue is made of several types of neurons, which has axon. An axon is the stem-like part of the cell that sends nerve impulse to the next cell. Major groups of axons make up nerves in the Peripheral Nervous System (PNS) and connecting fibers of the nuclei of the Central Nervous System (CNS).

Neurons are cells with specialized features and possess a large soma/cell body with dendrites and an axon (both are forms of cell projections). Dendrites are projections branching that are thin that receive electrochemical signaling (neurotransmitters) to create a change in the voltage in the cell. Axons carry action potentials away from cell body toward the next neuron. They are long projections. The bulb-like end of the axon (axon terminal) is seperated from the dendrite of the neuron following by the synaptic cleft. When nerve impulse travels to the axon terminal, the neurotransmitters are sent across the synapse where it is received by the post-synaptic receptors continuing the communication.

Following harm to a peripheral nerve, the damaged axons declines in quality. In a few weeks, they regenerate and from thence recovered by myelin (insulating sheath which envelops the axon). This myelin enables rapid transmission of electrical pulses. However, the Schwann or glial cells do not regenerate the myelin sheath completely. Hence, the function of damaged nerves often remain impaired and certain muscles paralyzed in affected patients.

It has been proven that the growth factor neuregulin1 supports nerve repair and the redevelopment of the myelin layer.This protein is created by neurons and stationed on axons where it operates as an important signal for the development of Schwann or glial cells and myelin formation. In lieu of the rapid degeneration of axons after injury, the Schwann cells remaining lose communication with axons. Hence, there is a lack of neuregulin1 signal of the nervous fibres.

Synthesizing the neuregulin1 protein until axons are fully grown, has been shown to develop the Schwann cells and regenerate the myelin sheath after injury. From thence the neuroglia cell will contribute to the repair of the myelinated axons.

However there is another problem, the scar tissues that develop in the healing process post operation.

V. GAASSI CHIP APPLICATION

Once surgeons have performed the operation, the GaAsSi Chip(s) will be placed above and/or below the affected area (separate from the implantation in the brain), along the vertebrae column.The purpose of this implantation is to stimulate the area affected with electro-magnetic propagation.The electrodes, which may vary in size in this situation, will be placed appropriately so as to effect proper therapy. This is in an attempt to heal the scar tissues that arise.

In a study done by Perea Clinic Ltd London, frequencies in the region of 0.8MHz to 1MHz has been known to heal scar tissues.

It involves the use of a round-headed wand (probe) that…produces a wave that vibrates at about 0.8 to 1.0 Mhz…produces a vibration of the local tissue. [15]

However, in a study done by scientists from Germany suggests frequencies in the region of 510kHz to 4.36MHz.

Here, the responses of …neural stem cells were investigated to…combination treatments between 510 kHz–3 W s/cm^2 and 4.36 MHz–25 W s/cm^2…showed enlarged neurospheres…Differentiation was not impaired…[17]

From the studies above, it appears frequencies in the region of 510kHz to 4.36MHz have the bandwidth and propagation to treat these scar tissues. A further study shows that increasing the wattage to 600 W s/cm^2 has been proven in mice

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to remove the malignant cells that cause scar tissues to develop.

The GaAsSi chip will have the potency to generate wattages up to 1000 W s/cm^2 and greater. This will have the capability to prevent and remove the malignant cells forming scar tissues and improve bloodflow giving the brain passage to communicate with parts of the body previously unreachable due to injury. However, caution has to be taken because wattages of these amounts can greatly displace neurons (beyond their determination point).

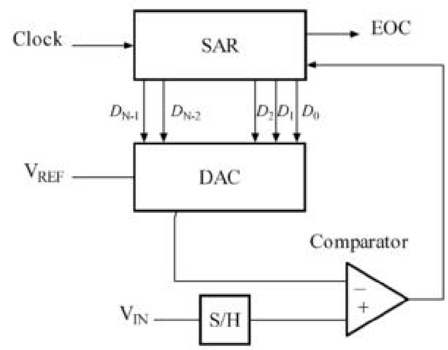
Once the Medical Doctor applies 600 W s/cm^2 (or so) to the area affected, he/she will have to monitor the area consistently using the appropriate frequencies to make certain the patient is not over-doped with radiation. When the malignant cells have been fully removed and/or the area properly sustained then the Medical Doctor (MD) can cease the radiation.

The chip implant in the brain is necessary to teach the brain to improve its own internal frequencies and wattage to exceed the appropriate thresholds to make proper communication down the spinal column. The brain does this by using its own internal metals (iron, copper, magnesium, zinc, etc.) and nutrients responsible for hemoglobin to generate frequencies which will then be propagated down the vertebrae column. This is once a proper operation has been done and the proper treatment(s) given to the patient.

This will especially be beneficial during therapy and helping patient to gain motility in limbs previously unreachable due to injury. Proper therapy should be given to patient to help train patient to use limbs once again.

The GaAsSi chips will be able to speak wired and wirelessly with each other (inclusive of chips implanted in the brain) and with the external computer. The user of the machine/computer, according to preference, will be able to synchronize and desynchronize the GaAsSi chip(s) in its functions and operations.

Sample Analog to Digital Conversion:



Successive-approximation ADC block diagram

Fig.4.1: Analog to Digital Conversion

Key

DAC = digital-to-analog converter

EOC = end of conversion

SAR = successive approximation register

S/H = sample and hold circuit

V_{in} = input voltage

V_{ref} = reference voltage

SAMPLE PROGRAM/CODE (in C++)

```
#include <library ieee>

#include <ieee.std_logic_1164.all>

#include <ieee.numeric_std.all>

#include <iostream.h>


void main{

int ADC_8_bit {
```

```
float analog_in;
  port (analog_in(float a >= -15.0 && a =< +15.0)
digital_out: out std_logic_vector(int b > 7 && b=< 0)

} return 0;

ADC_8_bit =constconversion_time (float time = 25 ns);

  signal instantly_digitized_signal :std_logic_vector(b > 7 && b=< 0);
  signal delayed_digitized_signal :std_logic_vector( b > 7 && b=< 0--);

  int ADC_8b_10v_bipolar (
analog_in (a>= -15.0 && a=<+15.0)
  ) return std_logic_vector =
const intmax_abs_digital_value= 128;
const float max_in_signal= 10.0;
    float analog_signal;
    float analog_abs;
   float analog_limited;
    int digitized_signal;
    int digital_out: std_logic_vector(b > 7 && b=< 0);
  {
analog_signal= (analog_in);
    if (analog_signal< 0.0) {  intip< 0;
digitized_signal= int(analog_signal * 12.8);
      if (digitized_signal< -(max_abs_digital_value)) {
digitized_signal = -(max_abs_digital_value);
      }
}
    else {
digitized_signal = analog_signal * 12.8;
if (digitized_signal> (max_abs_digital_value - 1)) {
digitized_signal= max_abs_digital_value - 1;
      }
    }
digital_out= std_logic_vector(to_signed(digitized_signal, digital_out_length));
```

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```
  return digital_out;
 } ADC_8b_10v_bipolar;

{

instantly_digitized_signal<=
std_logic_vector (ADC_8b_10v_bipolar (analog_in));

while (instantly_digitized_signal>= conversion_time){

delayed_digitized_signal<= instantly_digitized_signal;

digital_out<= delayed_digitized_signal;

}
}
cout.flush();
}
```

There will be a hard (burnt-in) and soft address to facilitate security concerns. Therefore, the internal chips will only communicate with each other and a specific computer(s) unless they are officially programmed otherwise. With respect to data communication, 5G (and higher) data communication will be required to guarantee proper sync between internal chips and external computer(s).

VI. THE GAASSI ARCHITECTURE

The GaAsSi Chip consists of Stimulation, Electrode Diagnostics, Power Management, Analog Amplifiers, Analog-to-Digital Converters, Processing Logic, 5G (and higher) Radio Frequency (RF) Transceiver and/Sensor Feedback. This connects to a Data Transfer Coil, which connects to a computer terminal. The Cable Connectors will be placed just under the epidermis.

The Manufacturer (or Authorized Personnel) would have the right based on user request to remotely troubleshoot any technical issues that may develop during use of the chip (where necessary), or user could go in for in-person adjustments to the chip (of course upon certification and assistance from a MD). However, the GaAsSi Chip(s) would be programmed as such to automatically raise a flag in the event of any technical issues that may develop during its use.

The GaAsSi Chip Implantation consists of twelve (12) Application-Specific-Integrated Circuits (ASICs) each containing 500 to 1000 electrodes. This results in 6, 000 to 12, 000 individually programmable amplifiers and 6,000 to 12,000 channels overall. This will enhance better reception of analog signals to the brain and transmission of signals thereto. The Language of choice is C++. Overall, there will be four (4) Chip Implantations in the brain and as a result 24,000 to 48,000

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electrodes from the Sensors to the External Computer.

7.1 STIMULATION:

Brain stimulation therapies can play a role in treating certain mental disorders…therapies involve activating or inhibiting the brain directly with electricity. [5] The electricity is applied through electrodes inserted in the head or placed on the scalp of the subject. It is possible also for electricity to be induced through the use of magnetic propagations to the head. This is beneficial because it has been proven to help persons with neurological disorders.

From the Scientific Data/Information presented under "THE HUMAN BRAIN: NEURO-TRANSMITTANCE", the synaptic nerves respond to different frequency levels. Hence, the Stimulation Engine would be so designed that 6 ASICs (with their respective electrodes) would be placed among monosynaptic nerves and 6 ASICs (with their respective electrodes) would be placed among disynaptic nerves. Generally, a 50/50 rule relatively.

When the sensors detect a lapse in communication from the synaptic nerves the Chip will detect such lapses and is automatically configured to generate the appropriate frequencies to stimulate such nerves. From research disynaptic nerves responds best to frequencies in the range of 50 to 200 Hertz, while monosynaptic nerves respond best to frequencies in the range of 10 microhertz and lower.

In disynaptic nerve communications lapse, the Stimulation Engine will generate 50 to 200 Hertz to stimulate activity. It will do this over a 30 second to 2 minutes period. It will automatically increase by the tens until positive responses are detected. While in monosynaptic nerve communications lapse, the Stimulation Engine will generate in the range from 10 microhertz to10 nanohertz to stimulate activity. The Stimulation Engine in this situation will do continuous (non-time specific) frequency propagation until positive responses are detected. However, Medical Doctors will have the option to perform these functions manually or to configure the device according to preference.

The generally advisable amount is ten (10) seconds per frequency (Hz) testing, before increasing or decreasing frequency variable, when stimulating nerves. The electrodes read electrical pulses between axons and also stimulates dendrites and neurons. However, this will not affect neuro-transmission due to the dipole moment between axons. [This applies to both CNS and PNS]

The reason for the above approach, is that research has shown that monosynaptic nerves respond best to low continuous frequencies and disynaptic nerves respond best to short periods of high frequencies. Even though low frequency monosynaptic nerve(s) stimulation does trigger disynaptic nerve(s), the disynaptic nerves themselves respond to higher frequencies.

General Formula:

$$S_{AM} = -0.5[\cos(2\pi(f_c + f_m)t) + \cos(2\pi(f_c - f_m)t)], \quad (1)$$

$$S_{FM} = \sin(2\pi f_c t + M \sin(2\pi f_m t)) \quad (2)$$

Where AM is Amplitude Modulation, FM is Frequency Modulation, f_c is Carrier Frequency, f_m is Message Frequency, t is period (in time) and M is Modulated Signal.

7.2 AMPLIFIERS AND ANALOG-TO-DIGITAL CONVERTERS:

An electronic amplifier is an electronic system that increases voltages. The system's power supply provides the energy required for amplification. A perfect amplifier does not interfere with the input signal. The output is an exact reproduction of the input signal but of increased pitch. It is a live quadripole based on active component(s), for example, transistor and operational amplifier.

Electronic amplifiers are implemented in most electronic circuits. They are able to give rise to electrical signals, in the case of a sensor's output, to a level of voltage that can be used by

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the rest of a given system. They can also improve the maximum power that a system has available and can provide to power to a charge such as a speaker and radio antenna.

Pixel Aspect Ratio (PAR) is a mathematical ratio that defines the proportionality of the width of a pixel in comparison to the height of that pixel.

The Display Aspect Ratio (DAR) is the ratio of the height of an image*;* for TV, DAR was traditionally a four-to-three ratio, 4:3 (full screen) and a sixteen-to-nine ratio, 16:9 (widescreen) the present standard for High Definition TV. With the Storage Aspect Ratio (SAR) for Digital Imagery, there is a difference, that is, the ratio of pixel dimensions. When the image is displayed with pixels of equal width and height, then ratios are said to agree, otherwise they disagree.

The Pixel Aspect Ratio (PAR) is related by the identity:

SAR × PAR = DAR (3)

The square pixels are 1:1.

Rearranging yields:

PAR = DAR/SAR (4)

A 680 × 520 Video Graphics Adapter image has a SAR of 680/520 equaling a four-to-three ratio, and if previewed on a four-to-three ratio display (DAR = 4:3) has square pixels, hence a PAR of an one-to-one ratio. On the contrary, a 744 × 600 D-1 Phase Alternate Line has a SAR of 744/600 equaling a five-to-four ratio, but is displayed as a DAR equaling a four-to-three ratio.

There is no SAR or PAR in analog images, but in digital conversion of analog images, the digitized form has pixels.

7.2.1 The Application of Laplace And Fourier Transform

7.2.1.1 Laplace Transform

The essential component of the Laplace transform takes the differentiation of components and multiplies them by:

for s = (σ,ω) (5)
$L(f')(s) = sL(f)(s) - f(0)$

Given the differentiation of product rule: (uv)' = u'v + v'u, integrating both sides gives (6)

$u(b)v(b) - u(a)v(a) = \int_a^b (uv)' = \int_a^b u'v + \int_a^b uv'$

Therefore, the $u=e^{-\sigma t}(\cos(\omega t), -\sin(\omega t))$, and $dv = f'$, there is $u'=(-\sigma,-\omega)u$, and $v=f$, and (7)

$0\, f(\infty) - 1\, f(0) = (-\sigma, -\omega)\int_0^\infty f(t)\, e^{-\sigma t} (\cos(\omega t), -\sin(\omega t)) + \int_0^\infty f'(t) e^{-\sigma t}(\cos(\omega t), -\sin(\omega t))$Type equation here.

so that

$L(f')(s) = sL(f)(s) - f(0)$

The important matters here are that the differentiation of the product rule and the situation that differentiating lowered oscillation(s) results in multiplication of that/those oscillation(s) by a constant value.

7.2.1.2 Fourier Transform

Periodic functions can be approximated by Fourier series. This result is likely to be broadened to express any procedure as an integral of sine and cosine components. Let f be a function and define f_T to be the periodic extension of f on the interval -T/2 to T/2, that is, $f_T = f$ on the interval -T/2 to T/2 and f_T is periodic with period T. Then f_T is an estimated value of a Fourier series. The Fourier series utilizes multiples of frequencies that are based on frequency 1/T cycles per second. As T goes up in numerical value, f_T value goes to f, so the spacing in between the approximated frequencies, that is 1/T, decreases. In the limit, a replacement of the summation of the integral series is necessary. The Fourier Integral Theorem is where the integral equals f. The variables of the sine and cosine individual composites are stated by the Fourier transform.

Fourier cosine transform and the Fourier sine transform derives the Fourier Transform. The Fourier cosine transform series f is explained by any frequency deemed realistic by λ cycles per second is (8)

$A_f(\lambda) = 2\int_{-\infty}^{\infty} f(t)\cos(2\pi\lambda t)$

and the Fourier transform of the value f is discussed as (9)

$B_f(\lambda) = 2\int_{-\infty}^{\infty} f(t)\sin(2\pi\lambda t)$

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The Fourier Integral Theorem (FIT) explains that
(10)

$$f(x) = \int_0^{\infty} A_f(\lambda)\cos(2\pi\lambda x)d\lambda + \int_0^{\infty} B_f(\lambda)\sin(2\pi\lambda x)\,d\lambda$$

It is assumed $f(x) = 0$ for $x < -T_0/2$ and $x > T_0/2$. It is believed f the transform of sine is 0. The values of the Fourier series for f_T (were f_T matches f for $-T/2 < t < T/2$, and relates to be congruent with specific periods of time (T), which are then (11)

$$A_j = A(j/T) = 2/T\int_{-T/2}^{T/2} f(t)\cos(2\pi jt/T) = 2/T\int_{-\infty}^{\infty} f(t)\cos(2\pi jt/T) = A_f(j/T)/T \text{ for } j = 0,1,2...$$

It is estimated that FIT integral by splitting the range of waves into intervals of size h=1/T and adding with
(12)

$$\int_0^{\infty} A_f(\lambda)\,cos(2\pi\,\lambda x)d\,\lambda <\!\!- (1/T)\sum_{j=0}^{n} TA\left(\frac{j}{T}\right)\cos\left(\frac{2\pi jx}{T}\right) = \sum_{j=0}^{n} A\left(\frac{j}{T}\right)\cos\left(\frac{2\pi jx}{T}\right) = S_n(f_T,x)$$

7.2.1.3 Explanation

In simple terms, Laplace and Fourier Transform are used in conjunction with each other to mitigate against the Nyquist Effect and bring sinusoidal (and other types of) waves to its pure form. Signals are amplified using Laplace Transform and hence exceeding the threshold to overcome noise/attenuation on a channel(s). Fourier Transform is then used to sub-divide sinusoidal waves (and also other types of waves) into periods of time. Here signals are looked at introspectively to remove any other electromagnetic interference and extract data for digitization and hence conveying an accurate representation of analog data in binary form.

The processing of the analog waves occurs 100 picohertz. The Microprocessor Implantation accepts 80, 000 samples per second (80 milliseconds or 80 Megabits per second) and process them using 16 Core Computers. This Operation overall happens so fast that the brain will not recognize.

The Nyquist Theorem is a principle in the digitization of analog signals. For analog-to-digital conversion (ADC) to result in a faithful reproduction of the signal, the analog waveform must be taken frequently. The Nyquist Effect is when signals become halved when they exceed a certain threshold(s) (that a given system is unable to keep up with).

Any analog signal has several frequency elements. An example, the sine wave where all energy is concentrated at one frequency. Analog signals have complex waveforms with varied frequency elements. The highest frequency measurement dictates the bandwidth for that analog signal. Frequency is proportional to bandwidth, if all other considerations remain the same.

The Nyquist Theorem for a given analog signal f_{max} is at least $2f_{max}$. The sampling converter from continuous to non-continuous signal is actuated by a clock (or pulse generating device). If the sampling rate is less than $2f_{max}$, the highest frequency components are not guaranteed be correctly represented in the digitized output. When such a digital signal is converted back to analog form by a digital-to-analog converter, it does not return to its original analog signal or even near so. This undesirable condition is an aliasing/distortion.

The Nyquist–Shannon sampling theorem serves as a fundamental bridge between continuous-time signals and discrete-time signals. It establishes an appropriate situation for a sample rate that permits a discrete sequence of samples to capture all the information from a continuous-time signal of bounded/limited bandwidth.

The theorem is applicable to a class of mathematical functions having a Fourier transform that is zero outside of a certain region of frequencies. It is anticipated that when a continuous function reduces to a discrete sequence, it returns to a continuous function, the fidelity of the result depends on the sample rate of the original signals.

The theorem for experimentation (or sampling) is designed so that no information is lost and that

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the actual fidelity for the class' hierarchy to certain bandwidth is band-limited. It shows the sampling as an expression of the bandwidth for specific hierarchy of function(s). The theorem is effectively a formula for the reconstruction of the original continuous-time or analog function from collected waveforms.

Perfect reconstruction is probable even when the sample-rate criterion is not satisfied, given other limitations on the signal are established. In some situations, where the sample-rate criterion is not met, using additional constraints allows for estimated reconstitution. The fidelity of these reconstitutions can be verified and quantified with Bochner's theorem.

7.3 FREQUENCY (RF) TRANSCEIVER:

With carrier aggregation (CA) and advanced-MIMO techniques, the New Radio (NR) devices can attain up to several Gb/s peak data-rate. The demand of high bandwidth has created a need for exploring high-frequency spectrum over 3GHz, while sustaining legacy Long Term Evolution (LTE) bands for LTE-NR dual connectivity (EN-DC). Since User Equipment (UE) requires small form-factor and low power consumption, a single-chip RF transceiver is essential to cover both NR and legacy protocols, simultaneously. This integrated CMOS (complementary metal-oxide-semiconductor) Radio Frequency Integrated Card (RFIC) that supports multimode and multiband applications including all the legacy 2G, 3G, 4G and stand-alone/non-stand-alone sub-6GHz 5G NR features.

According to the Third Generation Party Project (3GPP) (release 15) standards, 5G NR (New Radio) is able to operate in two frequency bands, that is, FR1 and FR2. A transceiver (TRx) operating in Time Division Duplex (TDD) mode at 3.5 GHz (FR1 band) is chosen for analysis. A band pass filter is a very essential component in wireless transceiver (TRx) systems. The system specification and Radio standards requirement are stated in detail by the Filter's specification. Filters play a major role in making the system more immune to unwanted radio signals, improving the selectivity of the receiver and rejecting spurious harmonic noise generated within the system.

The Tx chain contains a cascade of driver amplifier that conditions the input signal, a Band Pass Filter (BPF) operating at the desired frequency band, and a power amplifier (PA) to improve the pitch of signals to a required level for the antenna to transmit. The Rx chain consists of a low-noise amplifier (LNA) to increase the signal power to an appropriate level for detection with the Band Pass Filter as a digital attenuator for adjusting the gain of the system and also an amplifier (AMP) for processing the signals. The antenna is joined to the Tx and the Rx chain through a single pole double throw (SPDT) RF switch. In conjunction, a directional coupler (DC) can be placed after the antenna for supervision and standardization purposes.

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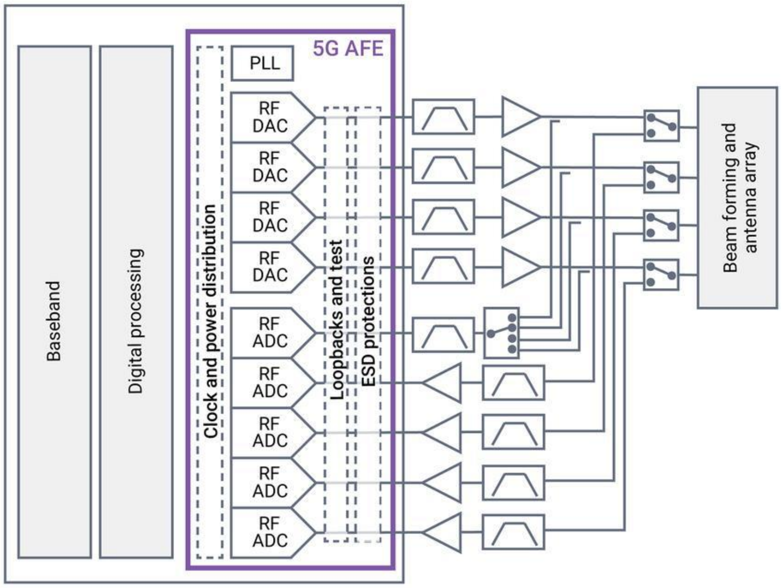

Fig.5.1: 5G RF Transceiver Architecture

7.4 ELECTRODE DIAGNOSTIC:

The medical electrode passes ionic current's energy to the (human) body as electrical current that can be made higher pitched, researched and used for medical purposes.

Medical electrodes allow for fundamental verification of internal ionic current. This yields a radical test for varied nervous, muscular, ocular, cardiac, and other illnesses that would have otherwise required surgery to establish. Muscular examinations may disclose evidence of diminished muscle fiber(s) and reveal muscle disorders and neurologically-based illnesses along with discovering whether or not muscles are weak. The electrodes are inexpensive, easy to control, can be disposable or sterilizable and very unique in the task they perform. The main purpose of the electrode is to create proper electrical communication between the patient and the apparatus used to measure and/or record activity.

7.5 PROCESSING LOGIC:

This coordinates all the activities of the Chip(s). Processing Logic is a ruggedized computer used for industrial automation. These controllers provide automation of a specific function/process and as well a complete manufacturing operation.

The Processing Logic receives information from connected sensors or input devices, processes the data, and triggers outputs based on pre-programmed parameters. Depending on the inputs and outputs, a Processing Logic can monitor and record run-time data such as machine productivity or operating temperature, automatically start and stop processes, generate alarms if a machine malfunctions, and more. Processing Logics are a flexible and robust control solution and are adaptable to any application.

7.6 POWER MANAGEMENT:

The Power Management System is designed according to Advanced Configuration and Power Interface (ACPI). ACPI is open standard that Operating Systems use to discover and configure hardware components to perform power management operations such as putting unused components to sleep and perform status monitoring.

The Power Management System is used to: reduce overall energy consumption,

prolong battery life for portable and embedded systems, reduce cooling requirements, reduce noise and reduce operating costs for energy and cooling.

Lower power use means lower heat dissipation (leading systems stability) and less energy use and that reduce costs and reduce negative impacts on people and the environment.

7.7 SENSOR FEEDBACK:

Sensor is a device, module, machine, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor. [12]

The Sensor(s) relating to the GaAsSi chips are used for interfacing with the Electrodes causing the external device to speak with the chips and vice versa.

Table: Specifications of GAASSI Implantation

Channels	24, 000 to 48, 000
Root Mean Square Noise	7.2 microvolts
Amplifier/Analog-Digital-Converter Power	3.3 microwatts
Spike Detection	2,000 nanoseconds
Stimulation Resolution	0.2 microamperes and 3.0455 microseconds
Die Size	4 x 5 mm

VII. CONCLUSION

Artificial Intelligence (AI) relates to the intelligence demonstrated by machines, in converse to that displayed by human beings. Any machine/device having the capabilities to recognize its surroundings and perform tasks to increase its chance(s) of successfully achieving its goals. AI describes machines ability to emulate cognitive actions that humans associate with the human mind in particular learning and problem solving.

The brain exhibits localization of functional areas, in that each brain region has a specific role, in sense. Most animal behaviour demands the collaborative and motor control areas of the brain and the activities of sensors. As the brain sensors undergo modification, the communication among brain areas adjusts depending on circumstances. When a new person is met, memorization of his or her face (encoding information) takes place, however when seeing the person again his or her face becomes recognizable and several events are associated with this person hence information retrieval. With the respective synaptic transmission between neurons, information processing is brought into effect. It is important to grasp that synaptic modulation can change communication among brain domains.

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